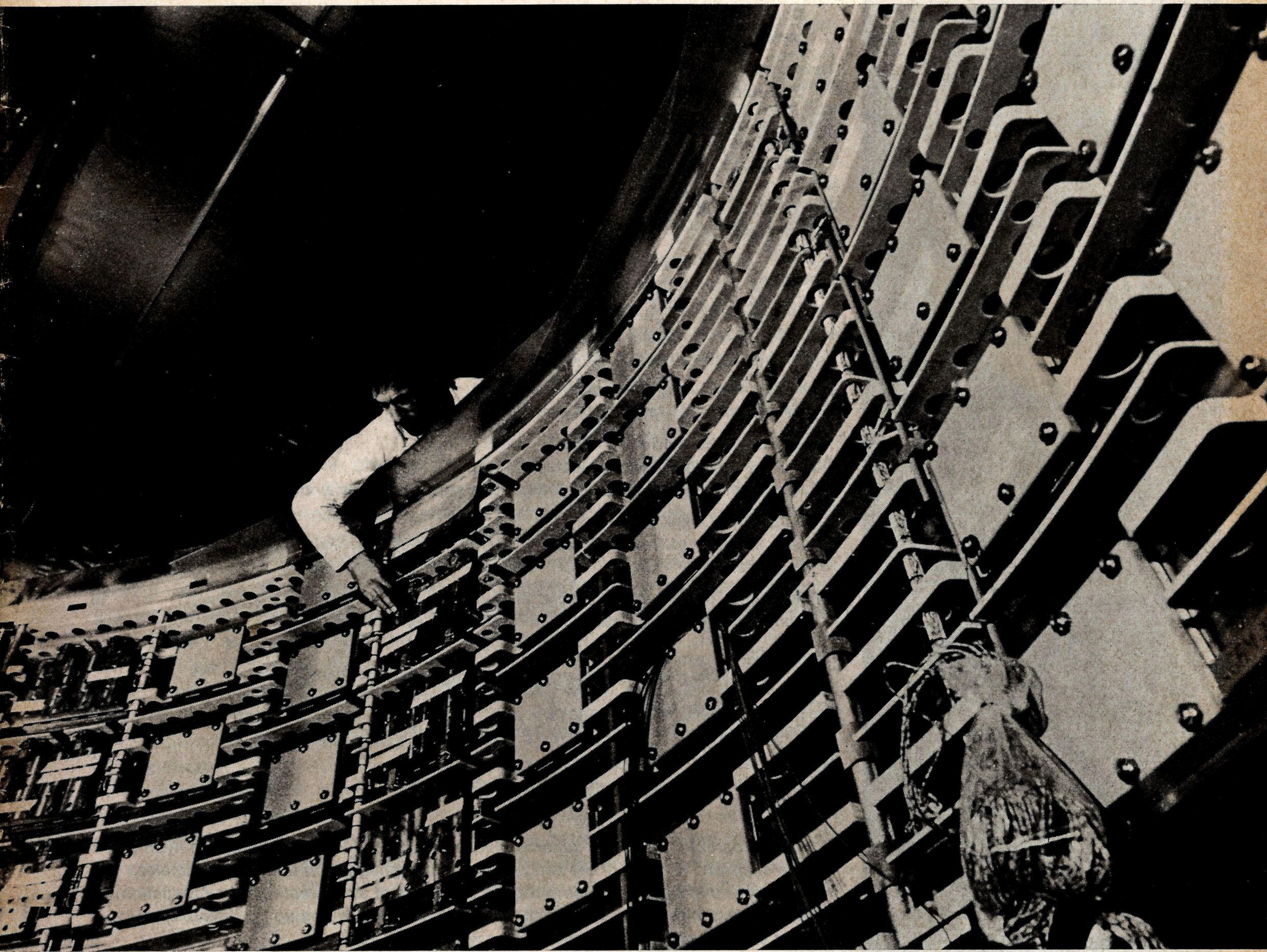
CERN COURIER

No. 1 Vol. 11 January 1971

European Organization for Nuclear Research



CERN, the European Organization for Nuclear Research, was established in 1954 to '... provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto'. It acts as a European centre and co-ordinator of research, theoretical and experimental, in the field of sub-nuclear physics. This branch of science is concerned with the fundamental questions of the basic laws governing the structure of matter. CERN is one of the world's leading Laboratories in this field.

The experimental programme is based on the use of two proton accelerators — a 600 MeV synchro-cyclotron (SC) and a 28 GeV synchrotron (PS). At the latter machine, large intersecting storage rings (ISR), for experiments with colliding proton beams, are being commissioned. Scientists from many European Universities, as well as from CERN itself, take part in the experiments and it is estimated that some 1200 physicists draw their research material from CERN.

The Laboratory is situated at Meyrin near Geneva in Switzerland. The site covers approximately 80 hectares equally divided on either side of the frontier between France and Switzerland. The staff totals about 3000 people and, in addition, there are over 650 Fellows and Visiting Scientists.

Twelve European countries participate in the work of CERN, contributing almost 350 million Swiss francs in 1971 in proportion to their net national income.

A project to construct a 300 GeV proton synchrotron on land adjoining the existing Laboratory, so as to provide first class research facilities in this field in Europe through to the end of the century, is awaiting authorization by the Member States.

CERN COURIER is published monthly in English and French editions. It is distributed free to CERN employees and others interested in sub-nuclear physics.

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1260 Nyon, Switzerland

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Cover photograph : Inside the superconducting magnet of the 3.7 m European hydrogen bubble chamber. Winding of the two poles of the magnet, which are 6 m in diameter, was completed in December. More than 12 000 hours of work went into the production of these poles. In the photograph can be seen the start of wiring up for the auxiliary circuits of the magnet which is now under way. (CERN 20.1.71)

300 GeV design

In the course of the past year a new design for the proposed European accelerator has been worked out by the '300 GeV Machine Committee' assisted by a series of Working Groups each specializing in some particular aspect of the machine. Representatives from all the European national accelerator Laboratories took part in the work which has thus pooled the ideas and experience of over a hundred European accelerator and particle physicists.

A two-volume report 'A design of the European 300 GeV research facilities' has just been published as a result of this study. Volume 1 is a summary of the whole design from which it is possible to draw all the essential features. Volume 2 is a series of reports from the Working Groups which spells out the detail design of each component part.

The final design will be carried out by the construction team when the project is given the go-ahead by the CERN Member States but it will probably remain very close to the design which has just been evolved and, in particular, the main machine parameters are unlikely to change very much.

The design, which we present in outline here, meets the specifications in the 'Programme Definition' (see vol. 10 page 307), the formal document laying down the essentials of the project, on the basis of which the Member States are taking their decisions. It achieves the required machine performance, in terms of beam energy and intensity, and ensures that the machine can be built within the agreed timescale and cost estimates.

There are two novel features which underlie many of the design decisions. The first is that the accelerator will be constructed alongside the present CERN Laboratory making it possible to use the existing proton synchrotron as injector and an existing experimental hall for research, at least in the initial years of operation. The second is the philosophy of extendible energy whereby the 300 GeV machine could be upped to higher energy ranges in the future, given further investment, should the progress of particle physics research call for it. Several design decisions make provision for such extensions so that they could be carried out as smoothly and economically as possible at a later stage.

Getting the protons in

The 300 GeV project will be off to a flying start since most of the injection system is already built and has been running successfully for many years! Proton beams will be ejected from the 28 GeV proton synchrotron along the beam transfer line (TT2) towards the Intersecting Storage Rings. At the junction where beams can either be fed to storage ring No. 1 or sent direct to the West Experimental Hall, a further tunnel 830 m long descending about 30 m, will be built to take protons under the Geneva-St. Genis road to be injected into long straight section No. 1 of the 300 GeV ring. A septum magnet followed by a kicker magnet will direct the protons into the ring.

The injection momentum is fixed at 10 GeV/c. This has the advantage (compared with higher energy) of reducing the amount of time for which the PS will be occupied accelerating beams to be used by the 300 and thus increasing the time for which it will be occupied providing beams for research at the 28 GeV level. (At present it is foreseen that the PS will give something less than one hour per day to filling the ISR with protons and the remainder to feeding protons on alternate pulses to the 300 GeV and to the 28 GeV physics programme. The 300 GeV will require one pulse about once every four seconds for 23 hours a day.) Also at 10 GeV, beam transport is simpler and less expensive and, after injection, the 20 bunches of the PS will take less time to smear out (debunch) ready for the acceleration system of the 300 to impose its own bunch pattern. (The total time for all the injection manœuvres will be about 0.2 s.) On the other hand, the energy of 10 GeV is sufficiently high to be comfortably away from space charge problems and it reduces the required accelerating voltage and accelerating frequency range in the 300 GeV ring compared with lower injection energies.

The precise method of ejection from the PS ring to the 300 has not yet been selected. Ejection techniques have improved so rapidly in the past few years that a range of possibilities, some of which will be further developed before the 300 is ready, are open. We will mention only what appears to be the most straightforward method at present — to eject single bunches from the PS at such time intervals as to distribute them evenly around the 300 GeV ring. (This imposes restrictions on the ratio of the 300 diameter to the PS diameter, restrictions which are in fact met by the proposed ratio of eleven — the 300 diameter being 2.2 km, the PS diameter being 0.2 km.) A twelve-module full-aperture kicker magnet (see vol. 10, page 379) will be available capable of handling high intensity beams, ejecting one or more bunches at 10 GeV by powering just four modules. A new technique to pulse kicker magnets at high speed has recently been proposed (see vol. 10 page 310) and will enable bunches to be ejected at 50 μs intervals so that all the bunches could be sent on their way to the 300 in 1 ms.

The ultimate beam intensity available from the 300 GeV accelerator will be

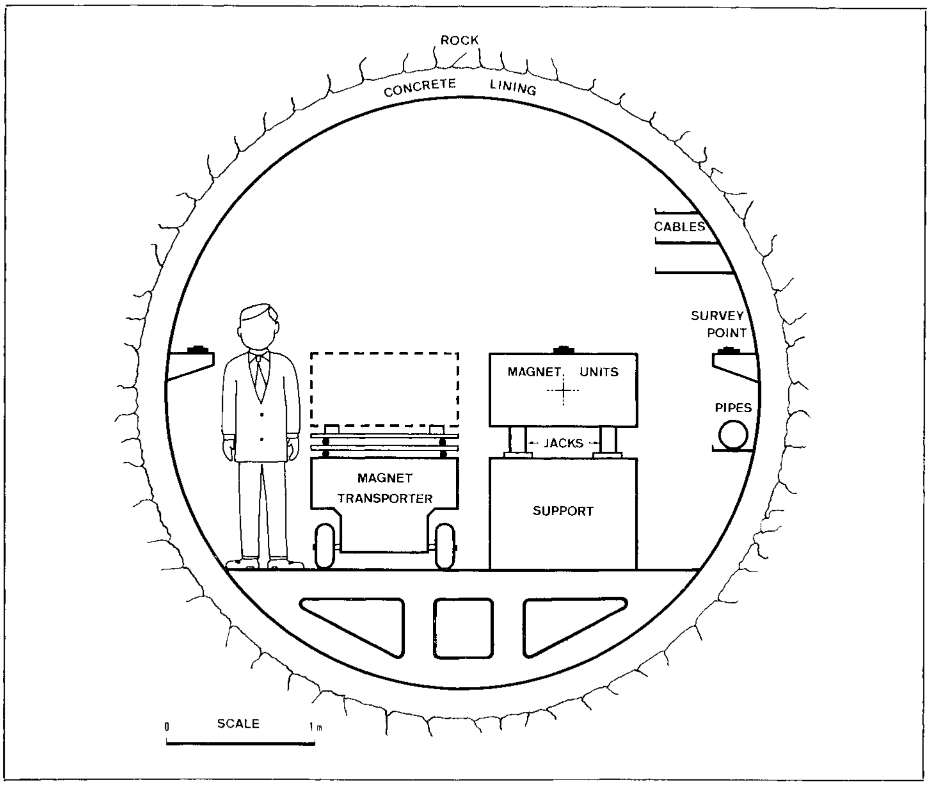


Figure 1 : A cross-section of the 300 GeV tunnel, 4 m in diameter, showing the proposed disposition of the magnets and their supplies. A magnet transporter, on which the magnets would be wheeled to their positions in the ring, accompanied by an impeccable gentleman is shown on the left.

limited by that which can be injected from the PS. At present, the PS operates at 2×10^{12} protons per pulse but when the 800 MeV synchrotron injector is brought into action this will be raised to 10^{13} protons per pulse. With the PS feeding the 300 once every 4 s, the average intensity at 300 GeV should be well above 10^{12} protons per second (the minimum intensity specified in the Programme Definition). Later, this intensity could be pushed to 10^{13} per second either by further development of the PS or by building a new injection system for the 300 GeV machine. It should be remembered that a lot is being asked of the old war-horse in proposing it as injector for the 300; before it starts to serve the new machine it is likely to have already endured over 110 million pulses.

The 300 GeV ring

The diameter of the ring, as mentioned above, will be 2.2 km. This is the largest that can be contained in the molasse ridge in which the machine tunnel will be bored several tens of metres below ground level. In fact, this diameter is greater than is needed for a 300 GeV peak energy (given the magnet field strengths which will be achieved) but spare diameter (or, more precisely, circumference) is an important card to have up the sleeve under the extendible energy philosophy.

The magnet 'lattice' will have different magnets performing the functions of forcing the protons to orbit the ring (bending magnets) and of keeping the beam focused (quadrupole magnets). In what follows we concentrate on the design for a 300 GeV energy and return later to the possible variants. As we walk round the ring we will meet magnets in the following sequence in one 'period', which then repeats itself

$$F\ s\ B_1\ g\ B_3\ g — g\ B_2\ g\ D\ s\ B_2\ g — g\ B_3\ g\ B_1\ g$$

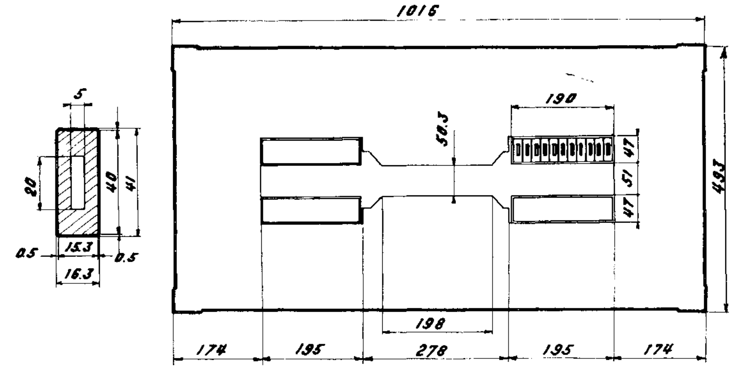
where F is a quadrupole which is focusing in the horizontal plane (length 3.799 m), s a short straight section (2.304 m), B a bending magnet (6.017 m), g an inter-magnet gap (0.6 m), — a space available for the insertion of a further bending magnet, and D a quadrupole which is defocusing in the horizontal plane (2.65 m). When the sums are done all around the ring, counting some special periods also, we arrive at 216 quadrupoles and 588 bending magnets. Into the lattice are inserted six long straight sections to accommodate the injection, the r.f. accelerating system, ejection to the West Experimental Hall and ejection to the North Experimental Area.

We will not spend much time on the quadrupoles. They are designed for optimum operation at 300 GeV but would cope satisfactorily at the 400 GeV level; their peak field gradients are 16.91 T/m (F) and 24.10 T/m (D). For maximum economy, the apertures are different in the two types so as to fit as close as possible around the beam profile which will vary from near circular in the D magnets to an ellipse flattened in the horizontal plane in the F magnets.

The bending magnets merit a little more attention since the design of these components has been the subject of much discussion in recent years. This discussion was prompted by the bending magnet design of the Batavia 200-500 GeV accelerator (described in detail in vol. 10 page 180) which is radically different from any previous design. By reducing the size and achieving technical simplicity they gained major economies. Fashion conscious observers have termed them mini-magnets by comparison with their maxi predecessors of 50 s and early-60 s design. With typical European flair for compromise, the currently favoured design for the 300 GeV sits between them — the midi-magnet. It is felt that this design is a balanced economic solution which has reduced the magnet system cost to 80 million Swiss francs (a satisfactory percentage (7 %) of the total programme cost).

Two types were studied — the 'H' magnet and the 'window-frame' magnet. The H type has its coils symmetrically above and below the mid-plane of the beam (the median plane); the window-frame type, as per Batavia, has coil also on the median plane closely surrounding the magnet gap. The H magnets are generally larger, weigh about 10 % more and require a greater stored energy of about 15 %. Also the window-frame magnets are capable of peak fields around 10 % higher. However, preliminary enquiries among several European magnet manufacturers indi-

Figure 2 : Cross-section of a bending magnet of type B1 ; the conductor with its water-cooling bore is picked out on the left. The coils are symmetrically positioned above and below the beam aperture and this design is known as an 'H' magnet. The dimensions are given in millimetres.



cated a cost about 20 % cheaper for the H type due to their greater technical simplicity. They are therefore, at present, considered the more economical solution as well as being the safer technical solution.

The diagram shows a B_1 bending magnet of the H type. The aperture is 132.7 mm horizontal and 36.6 mm vertical. Its length is 6.017 m. The design peak field is 1.8 T.

Power supply, Accelerating, Vacuum and Control systems

The magnet power supply will follow the new idea of 'static compensation' (see vol. 8, page 108) to avoid the need for large motor alternator sets to smooth out on the public electricity supply the effects of the large surges of power to and from the accelerator magnets. The static power supply method can only be used under certain conditions, for example, that the installed generating capacity of the public network is very large compared with the peak magnet pulse power. All the necessary conditions can be fulfilled for the 300 GeV by running a special 225 kV supply line to the Laboratory from Génissiat. All the power supply components will be capable of handling a 400 GeV energy level.

The accelerating system is of even more novel design. (Although the idea was put forward in the 1964 300 GeV design and successfully tested soon afterwards it has not yet been applied on a synchrotron.) It consists of three radio-frequency cavities, each 20.45 m long, installed in one long straight section of the machine, the cavities being of the travelling-wave type with a structure consisting of a circular guide loaded with transverse, horizontal bars and drift tubes. The protons gain their energy by being swept through the cavities on the wave generated in the cavities.

Since the required frequency swing with injection at 10 GeV is very small (0.44 %), the cavities can be of untuned, wide-bandwidth type requiring no ferrite or mechanical tuning system. The frequency will be 183 MHz resulting in 4224 proton bunches in the beam. Two r.f. amplifiers will drive each cavity giving an average power in each of 0.5 MW. There will be a phase lock beam control system similar to that used on the PS.

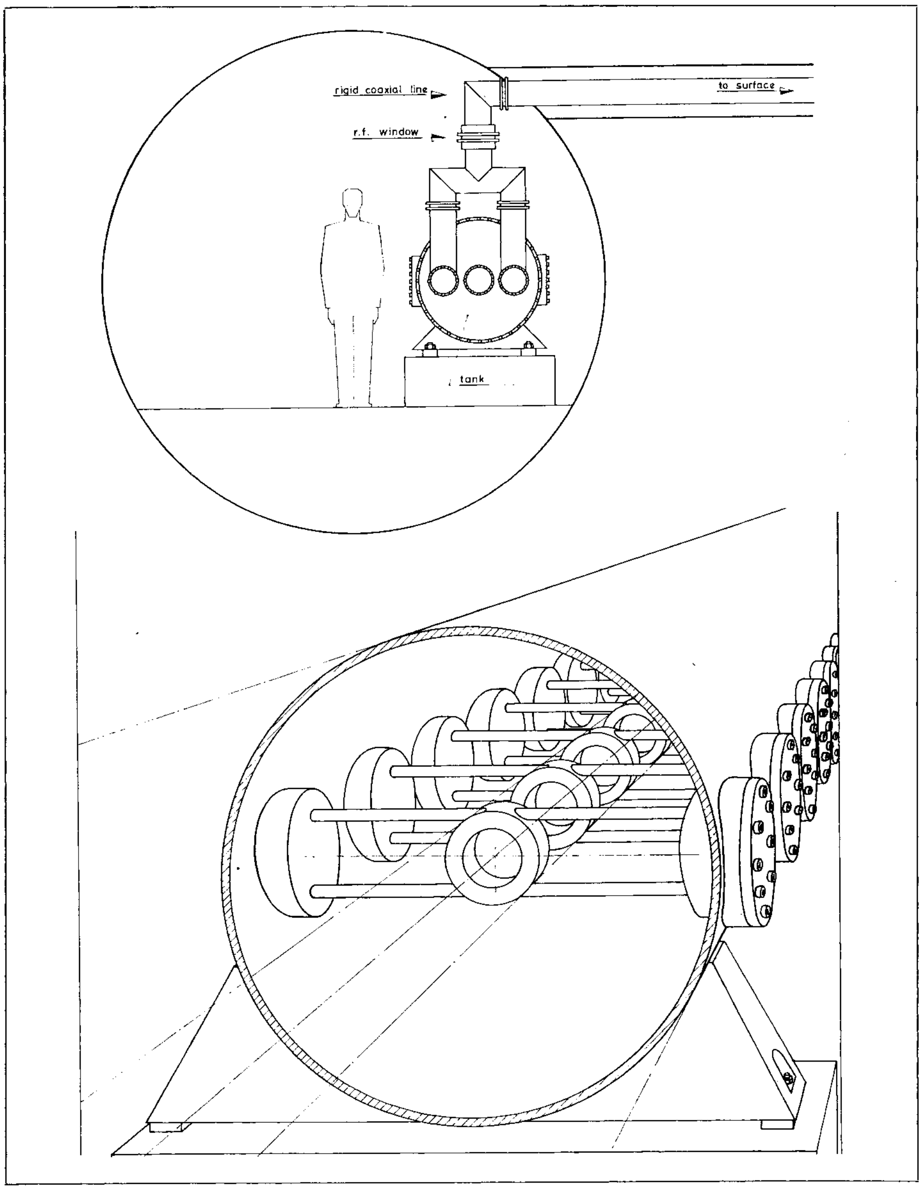
With the remarkable success of the vacuum system of the ISR behind us, where pressures around 10^{-10} torr are achieved around the rings, the 300 GeV requirements pose little problem. A pressure of 10^{-6} torr is considered adequate but to improve pump lifetime, 10^{-7} torr has been specified.

The vacuum chamber will be made of low permeability stainless steel insulated from the magnet and with ceramic sections to reduce eddy current effects. The chamber cross-section will follow the beam profile (as is obvious from the discussion of magnet apertures above). The chamber wall thickness, averaging around 2 mm, is still regarded as too much since it eats into expensive magnet aperture and more work will be done to see if it can be pushed lower. There will be 108 rotary pumps for the initial pumping distributed around the ring. Sputter ion pumps (432 around the ring), each with a pumping speed of 50 l/s, will achieve the ultimate pressure.

Techniques of computer control in accelerator operation have been developing rapidly in recent years (see vol. 9, page 166) and are being mastered to such an extent that it has been decided that the control system of the 300 GeV machine will be built around a computer. It will be impossible to operate the whole machine without the computer in action. Having taken this decision from the start, it will influence the design of all the components of the accelerator since they will all have to be integrated into the computer control system. Advantages will come from flexibility in the operating procedures and from the computer's ability to digest large quantities of data and to present essential information to the operators in easily assimilated form.

The system will involve a central computer with satellite computers (for example, looking after the r.f. system, the magnet power supply, the beam transfer lines, etc...). Because equipment is spread over large distances there will be need for multiplex data acquisition and control systems feeding into the satellite computers. The aim will be to make available all the necessary data and controls to a single operator.

Figure 3 : The radiofrequency accelerating system (accompanied by a rather more shadowy gentleman) at the point where the r.f. power is fed in and, below, looking into the structure inside a cavity.



Experimental Areas

Two ejection systems are planned to send protons towards the existing West Experimental Hall near the ISR and towards a new North Experimental Area. The efficiency of these ejection systems is crucial to the ultimate performance figures which the accelerator will achieve. Unless the efficiency is in the 99 % region it will not be possible to use very high intensity beams because the proton loss in the ring would bring intolerable radiation problems in its wake.

A three unit extraction channel has been designed. The first unit is an electrostatic septum of the type proposed a few years ago at Batavia and successfully tested at the PS (see vol. 10, page 85). It is capable of field gradients of 10 kV/mm (which is adequate for a 400 GeV beam) and has a foil 0.1 mm thick followed by a series of wires giving an apparent thickness of 0.15 mm over the 6 m length of the septum. The second unit is a more conventional copper septum (0.123 T for 400 GeV). The third is a pulsed iron deflecting magnet (1.5 T for 400 GeV) which will push the emerging beam upwards through an angle of 15 mrad. To avoid machine components in the ring less push is needed in the vertical direction than in the horizontal direction and, in any case, it gives the ejected beam a start on its climb from the ring tunnel deep underground to the experimental areas at ground level.

These units can be used both for slow ejection, where a resonance method would lure the beam to the ejection side of the first septum, and for fast ejection, where a full aperture kicker magnet would make the beam jump the septum in more violent fashion.

Just like the injector, the West Experimental Hall will be completed and ready before the 300. This is a novel way of building a new accelerator facility. It will be equipped in advance with two major research instruments — the 3.7 m European hydrogen bubble chamber and the Omega magnet-spark chamber system both of which are now being built. The ejected beam will approach the Hall climbing upwards through a tunnel about 900 m long where a beam transport system which copies the magnet lattice in the ring will be installed.

A detailed layout for beams in the Hall has been worked out involving the use of three target stations and providing eight secondary beams : a neutrino beam and r.f. separated beam (150 GeV/c) to the bubble chamber, a high energy beam for electronic experiments (150 GeV/c), two medium energy beams (75 GeV/c), a medium energy beam to Omega

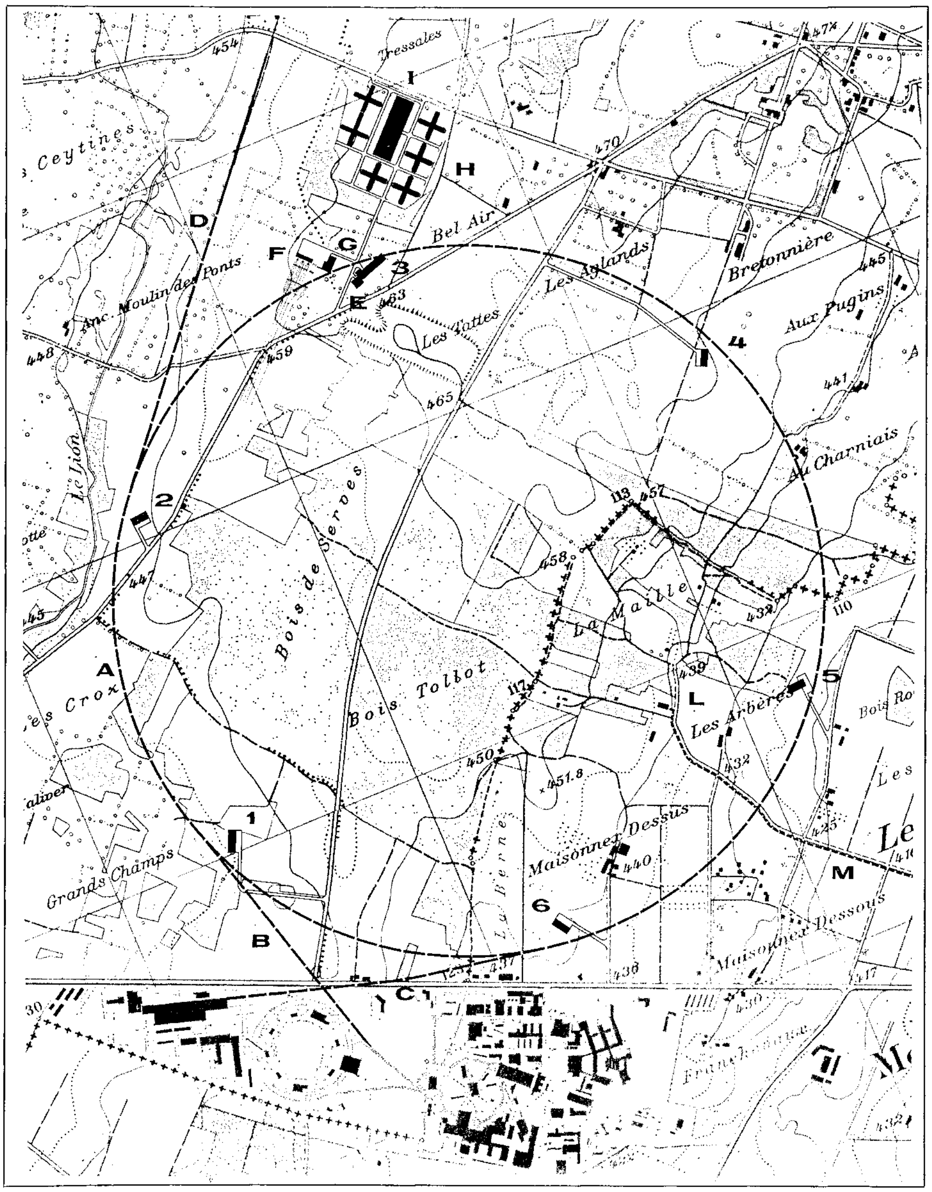


Figure 4 : The proposed site layout. The indicated points are as follows : A - main ring, B - injection tunnel, C - ejection tunnel to West Experimental Hall, D - ejection tunnel to North Experimental Area, E - main control room, F - main electrical sub-station, G - power house, H - laboratories and offices buildings, I - assembly hall, L - water reservoir and pumping station, M - pipeline bringing in cooling water from the lake, 1 to 6 - auxiliary buildings and access shafts.

(50 GeV/c), a low energy beam (25 GeV/c) and a neutral beam. The figures in brackets indicate maximum momenta from an incoming proton beam of energy 200 GeV.

The North Experimental Area has not yet been studied in much detail since there is time to draw on the experience at Batavia before layouts are prepared. It covers an area 600 m wide and about 4 km long within which the ejected beam could serve many target stations with ample room for secondary beams and experimental equipment. The appearance of this area is likely to be very different from the usual large hall choked with concrete shielding. It may be that only the detection equipment will be in buildings with all the beams running underground in shallow tunnels. The ejected beam could be brought up over a distance of 600 m to a level a few metres below ground at which level it could run the length of the area feeding target stations right and left. Everywhere, as far as possible, the natural earth would serve as the shielding.

The site

As befits present concern with environment, the planning of the 300 GeV Laboratory intends to leave the character of the existing country-side virtually untouched over the bulk of the site. Very small additions to the existing road network will be needed, there will be no interference with the small villages around the site, and farming and forestry can continue almost exactly as at present.

The machine will be built in a tunnel at an average depth some 30 m below ground level. This depth will ensure that, with the highest possible energies and intensities, the radiation levels on the surface will be well below the prescribed safety limits. The tunnel, 4 m in diameter will be bored by a special machine, guided by a theodolite-mounted laser, which is followed up by concrete lining. Nudging the driver's elbow at the appropriate point could also send the machine hurtling off down an injection or ejection tunnel at a rate of 10 to 20 m per day. Six vertical shafts will rise from the tunnel at the positions of the long straight sections where plant rooms will be built at ground level.

The rest of the buildings and site services will be clustered in one region near the machine and North Experimental Area. In this region also will be located the electricity sub-station to which the power line from Génissiat will come. The cooling water from Lac Léman will be brought to a reservoir further round the ring.

The energy options

In running through the design we

300 GeV Main Parameters

Ring diameter	2.2 km
Tunnel diameter	4 m
Tunnel depth (at shallowest point)	11 m rock and 7 m earth
Injection momentum	10 GeV/c
Injected intensity	10^{13} protons per pulse
Total transfer time from PS	less than 2 ms
Pulse repetition frequency	about 1 per 4 s
Number of r.f. accelerating cavities	3
R.f. voltage	3.7 to 5.4 MV
R.f. frequency	183 MHz
Maximum frequency swing	0.55 %
Maximum rate of increase of momentum	165 GeV/c s
Number of bunches in ring	4224
Number of bending magnets	588
Peak magnet field	1.8 T
Peak current in coils	3.41 kA
Peak power supply voltage	35.3 kV
Magnet length	6.017 m
Magnet aperture, vertical	36.6 to 54.9 mm
Magnet aperture, horizontal	79.1 to 132.7 mm
Number of quadrupole magnets	216
Peak field gradients (corresponding to 400 GeV)	16.91 T/m and 24.10 T/m
Quadrupole apertures	20.3×125.2 mm^2 and 49.0×53.5 mm^2
Mean power load on public supply	35.5 MW
Main ring pressure	10^{-7} torr
Overall programme cost	1150 MSF

have, for the most part, concentrated on what is needed for a machine with 300 GeV peak energy but have pointed out that practically all systems have a capability extending to higher energies.

To see where higher energy could come from we need to go back to the magnet lattice to understand the significance of '—', the space available for a further bending magnet. Such a lattice, known as a missing magnet lattice, has been discussed before (see vol. 10, page 109). It takes advantage of the fact that the proton orbits will vary only by centimetres for a doubling of energy in an appropriately arranged magnet system. The peak energy is dictated simply by the peak field in the magnets and the number of magnets.

The intention is to start construction of the accelerator by ordering magnets to achieve a peak energy of 200 GeV (leaving out two of the magnets — the B_3 type — of the magnet period spelled out above). Thus half the bending magnet space will be left empty.

Several years after the start of the project the situation with regard to the development of pulsed superconducting magnets will be assessed. If it looks as if such magnets are on, installation of conventional iron-cored magnets could be halted at this 200 GeV stage and preparations made for filling in the empty slots in the ring with superconducting magnets. A peak field of around 5 T may be feasible from these magnets and, switching off the conventional magnets using only the superconducting magnets, an energy approaching 500 GeV could be reached. Later the initially installed iron-cored magnets could be replaced by further superconducting magnets to give a peak energy approaching 1000 GeV.

If superconducting magnets are still not a safe bet by the time the decision on ordering magnets to go beyond the 200 GeV level has to be taken, conventional magnets to plug the lattice to the extent described in the section on the main ring above will give the prescribed project energy of 300 GeV. The 300 GeV lattice, thanks to the generous 2.2 km diameter, still has room for further conventional magnets which, when installed in the vacant spaces would give 400 GeV.

The costs and timescales specified in the Programme Definition cover reaching the energy of 300 GeV. Extra money would probably be needed to reach 400 GeV and it is impossible at this stage to foresee what the financial implications of moving to superconducting magnets might be.

The total cost of the 300 GeV project as designed is estimated at 1143.6 million Swiss francs, just below the ceiling of 1150 million laid down in the Programme Definition. This figure includes 472.9 million for the machine, 321.5 million for site equipment and buildings, and 249.2 million for staff expenses. The staff numbers will rise to a total of about 1000 over an eight year construction timescale. However beams at the 200 or 300 GeV level could be provided to the West Experimental Hall in the sixth year of construction and the last two years would see completion of the North Experimental Area going on at the same time as research. The project price thus includes an additional 100 million for operation of the machine during these last two years.

The new design of the European accelerator has these enticing options built into it. How the various possibilities will open up in the coming years adds an extra touch of spice to the 300 GeV programme.

General Outline of Scientific Programme for 1971

A description of the 1971 scientific and technical programme at CERN was prepared for the Scientific Policy Committee and was used to accompany the budget document. The opening chapter is reproduced here with a few minor modifications.

The year 1971 will be an exciting one for particle physics because the physics programmes at the CERN Intersecting Storage Rings and at the 400 GeV accelerator at Batavia will come into operation. Physics of 25 GeV has been explored during the last decade and turned out to be a very rich field. Important patterns have been found but it has not yet been possible to reach an understanding of elementary particles at the level which we have reached for atoms or nuclei. The first results from the 70 GeV accelerator at Serpukhov encouraged the hope that at higher energies important clues would turn up. Therefore, the big leap into a new energy range with the new facilities may bring the essential breakthrough in particle physics in the coming decade.

Although the two new machines will be in many ways complementary, there will be some overlap. One of the first experiments for both will be small-angle proton-proton scattering. The lowest energy at the ISR will just correspond to the highest energy at Batavia. The comparison of the results will not only check the new techniques to be used, but also provide a direct test for the theory of special relativity. Another experiment at the ISR which ties into things known from lower energy physics will be in process $p + p \rightarrow p + p^*$. Of course, there are many more projected ISR experiments looking at the production of known or perhaps as yet unknown particles.

Turning to lower energies, there will be one CERN experiment running at Serpukhov, namely the missing-mass spectrometer experiment. This instrument when operating at CERN discovered a wealth of new particles and is now in action at Serpukhov. It is to be expected that, as from the first CERN experiment, important results will emerge.

25 GeV physics at the proton synchrotron will have some novel facilities in 1971. The new beam-layout will include a hyperon beam. The track chambers equipment will be rejuvenated as the 80 cm hydrogen chamber is closed down and, instead of the 1.2 m heavy liquid chamber, Gargamelle is brought into operation. Using Gargamelle will make possible a neutrino experiment far superior to the previous ones, just before neutrino physics in the mid-1970's is completely taken over by Batavia. With these new features, the PS will, in 1971, be a dominant facility in particle physics.

The 600 MeV synchro-cyclotron will still in the coming years be an excellent instrument which has, with the ISOLDE programme, unique features. The shutdown for installation of the new radio-frequency system at the SC has been somewhat delayed so that the SC will be in full operation for practically the whole of 1971. It supports a large collaboration in nuclear physics and will continue its research on many other problems like muonic or pionic atoms.

Another feature of the 1971 programme will be the beginning of an increase in the number of Fellows and Visitors. The new facilities which will be offered by the improvement programme will enable CERN to serve more physicists from the Member States.

The ratio of 25 GeV and ISR physics versus improvement programme, in terms of expenditure, will be somewhat higher in 1971 than in 1970. However, due to a sharp increase of industrial prices during the year 1970, which was not foreseen and which is larger than is compensated by the cost variation index, some equipment for the new projects and for the West Experimental Area has become significantly more expensive. In 1971 this will involve transferring about 8 million Swiss francs from money planned for exploitation into the completion of the new projects. However, one can characterize the year 1971 as the year where the main part of the improvement programme will be completed and essentially only the Booster for higher energy injection into the PS will remain to be finished in the later years. Correspondingly, the use of the new facilities begins to dominate in this year over the construction costs which will drop to a stationary value in 1972.

CERN News

New Convention

Probably few people at CERN felt different on 17 January by comparison with the day before but on the stroke of midnight an event of potentially great importance in our lives had happened all by itself. Following acceptance by all the Member States, the revised CERN Convention came into force.

It is the Convention which spells out what CERN is and what it can do. The revised version (approved by Council at its meeting in December 1967 and described in detail in CERN COURIER vol. 8, page 56) essentially opens the door to a new Laboratory to accommodate the proposed 300 GeV accelerator. Since 17 January, legally, CERN can have a 300 GeV machine.

There is an unacknowledged law in physics, promolgated, if our memory serves us right, by R. P. Feynman, which says effectively 'If something can happen, it does happen'. We are waiting.

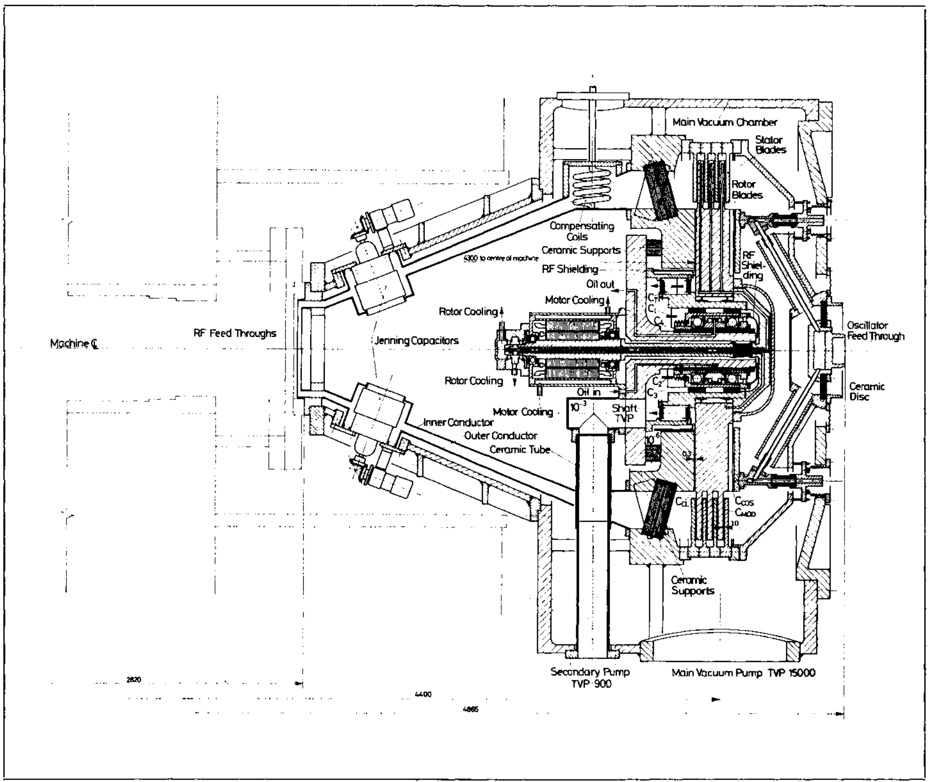


Diagram of the new radio-frequency accelerating system for the 600 MeV synchro-cyclotron.

The synchro-cyclotron's new r.f.

The most vital element of the improvement programme at the 600 MeV synchro-cyclotron is a new radio-frequency accelerating system. The programme is designed to increase the beam current (to 10μA), to improve the beam quality and to give a higher duty cycle. Many of the machine components need to be changed or modified to achieve the new performance but everything hinges on an r.f. system capable of providing the accelerating voltage necessary to raise the pulse repetition rate from the present 54 Hz to over 500 Hz.

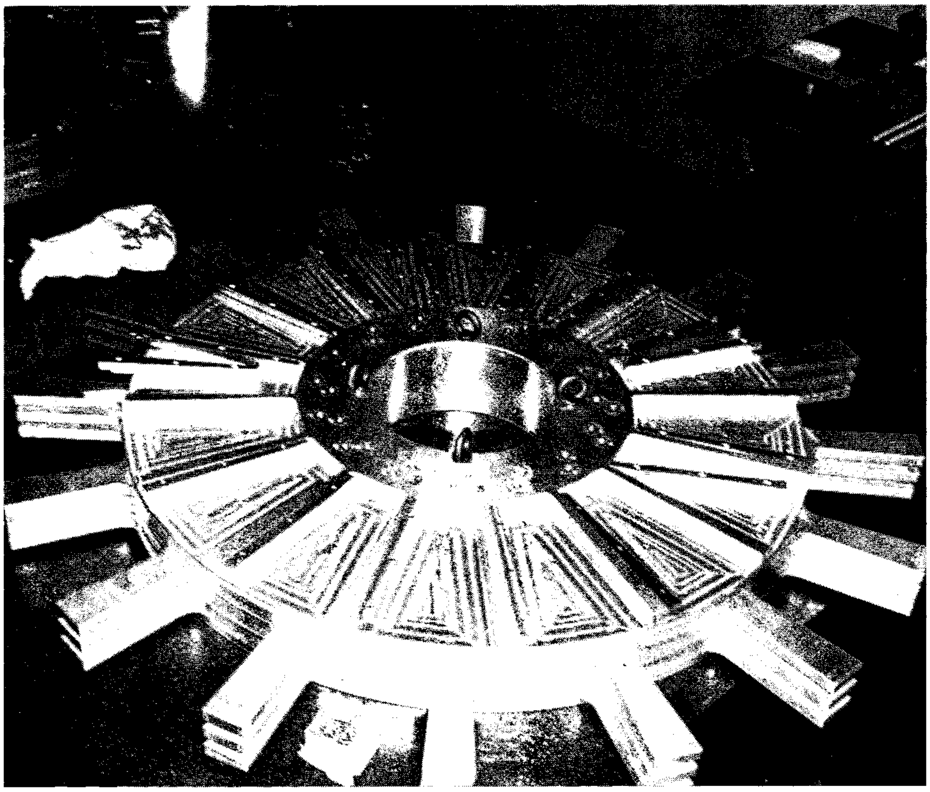
The high repetition rate, and the high voltages required to achieve it, necessitate the replacement of the present tuning-fork modulator by a mechanical rotating capacitor. This will vary the accelerating frequency from about 31 to 17 MHz according to a precise programme chosen so that no particles are lost during the acceleration. The alternative of a purely electronic modulator is excluded by the wide frequency range to be covered which would lead to an excessive power consumption.

Several years of design and model work have gone into evolving the design of the new system. The capacitor consists of blades rotating between fixed stator blades held at earth potential. The capacitance has to rise from 550 to 6500 pF during the acceleration cycle and the repetition rate is to cover a range from 380 to 650 Hz. Three assemblies are used, mounted on the same shaft, each of sixteen blades passing between the stators with a 1 mm minimum clearance. They give the capacitance change in one sixteenth of a revolution and are shaped to achieve the desired rate of frequency modulation throughout the accelerating cycle. The system operates in vacuum which introduces difficulties in the bearing design (where special precautions are needed because of the high r.f. fields also) and in the water cooling for the rotor blades.

The construction of the rotating capacitor, the complexity of which is only hinted at in the few lines above but which may be more apparent in the diagram, is obviously no picnic. The contract for this work is placed with AEG-Telefunken (Federal Republic of Germany) and they have met their fair share of problems during the past year. It was therefore with some relief that a 1:1 scale model, working with the final version oscillator, was brought into action at the end of last year. The model was successfully tested over the required frequency range.

The rotor for the 1:1 scale model of the rotating capacitor during assembly. The model was successfully tested towards the end of last year. The photograph shows the three sets of sixteen rotor blades (machined from a single block of dur aluminium) and, on the hub, the inlet and outlet holes for the cooling water which flows through the blades.

(Photo H. Beger)



Other elements of the r.f. system and other components for the improvement programme are well advanced. The first part of the new extraction channel is ready for tests. Manufacture of the support for the new ion source (which is introduced into the machine from below through a hole in the yoke) is beginning. A new vacuum tank has been ordered. The materials for the new magnet coils are arriving at CERN and winding of the coils will begin in February.

If all goes well, it is expected that the shutdown for installation of all these components will begin at the end of this year and will probably last about eight months. Magnetic measurements are likely to be the bottleneck and will be speeded by the use of an on-line computer. They will involve re-shimming of the central region where the magnet yoke will be pierced for the ion source and of the extraction channel region (to ensure that the channel itself does not perturb the nearby orbits).

By the end of 1972 a refurbished synchro-cyclotron will continue to serve as a top-quality machine in Europe covering the medium energy region, particularly until the 'next generation' cyclotron being built by the Swiss Institute for Nuclear Research at Villigen (see vol. 9, page 139) comes into action.

ISR Ring I does it again *

Commissioning tests on Ring I of the Intersecting Storage Rings (see vol. 10, page 343) began again on 11 January. This time the vacuum system was baked out all around the ring (giving an average pressure of a few 10^{-10} torr) and the clearing electrodes (to sweep out liberated electrons) were installed. It was hoped that this would bring about a major improvement in the rate at which the more intense stored beams decayed.

Right from the start, with stored beams of 0.5 A, the decay rate was unmeasurably small (below 10^{-4} per minute). Later, with the injection of 20 bunches from the PS, currents at the 2 A level were achieved with decay rates in the 10^{-3} per minute region the best being 6×10^{-4} per minute. The highest stacked current climbed to 3 A.

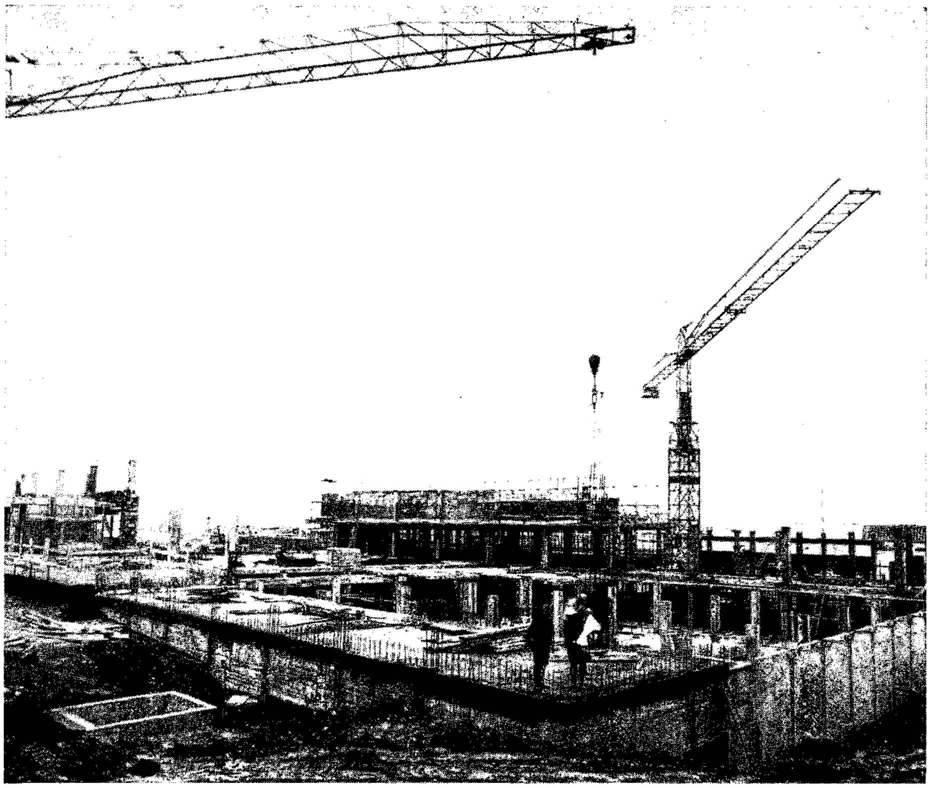
Though inevitably there were some instances of erratic behaviour, the ISR team regards the January tests as a breakthrough in that they have stacked and stored beams which would be usable for experiments. They have not run into any fundamental limitation on intensity and lifetime at the levels investigated. The slow, steady work of refinement continues. Ring 2 tests start at the end of the month and the next major hurdle will be to check that there are no serious problems coming from beam-beam interactions when both rings are in action.

In the course of these further ISR tests, the PS team did sterling work in keeping up the supply of protons. There was some trouble with the PS magnet power supply but inventive measures (lifting lids and blowing cold air on components which were becoming uncomfortably hot) kept the machine ticking over for the duration of the tests.

* *Stop press : Ring 2 brought into action 25 January. First collisions observed 27 January. Full story in next issue.*

New computer home

Construction of a new building for the Data Handling Division (located between the new restaurant and the Booster) is well advanced. The total floor area of the main Building will be 3500 m^2 with the biggest part (2500 m^2) taken up by a large hall 6 m in height which will be the new



The building to house the new central computer complex taking shape on the ISR site.

CERN 82.12.70

home for the central computers. (The growth of the computer system to include a CDC 7600 was described in vol. 10, page 348.) There will in addition be two wings providing 1500 m^2 of office and equipment area.

The most unusual feature of the building is connected with the need for careful temperature and humidity control of the environment in which the computers operate. A very powerful air-conditioning system for the hall (absorbing about 25 % of the cost of the building) is to be installed. It will cope with the heat given off by the computers retaining a constant temperature and humidity in both summer and winter.

The Technical Services and Buildings Division drew up the plans for the air-conditioning plant on the lines of other large installations already in existence. The air circuit selected is of the 'ceiling to ceiling' type as opposed to 'floor to ceiling' (which would introduce more of a dust problem to which computer tapes are very susceptible) or 'ceiling to floor' (which would involve an airflow in the opposite direction to that normal for cooling the computers). The system is being supplied by 'Applications Electriques SA' of Geneva in collaboration with Bergeon of France; the civil engineering work is in the hands of 'Société Aixoise de Construction'. The building is scheduled for completion in January 1972.

Emittance measurements at the ISR

Beam emittance measuring equipment has been installed in the ISR rings and in the transfer lines linking the PS to the storage rings. The measurements provided are mainly used to match the focusing properties of the magnet system to the beam emittance. The equipment has been in use for several months and was employed especially during the first tests on injection into the ISR in November 1970.

The operating principle is based on secondary emission from very thin aluminium foils arranged in parallel strips which are placed in the proton beam during a measurement. A positive signal, generated when the protons pass through the foils and proportional to the number of protons, is obtained from each strip; the secondary electrons which are liberated are swept away by clearing electrodes. The signals from all the foils define the beam intensity profile in the horizontal and vertical planes.

Since they are used in ultra high vacuum the units have to withstand bake-out at 300 °C, and they must therefore be of rather special construction. The aluminium strips are stretched by springs and fitted on a special ceramic support. Each measuring unit is secured at the end of a pivoting arm allowing it to be moved in and out of the beam or to have its position adjusted by half the foil spacing so that spatial resolution can be improved a factor of two when a measurement is made on a second beam pulse.

The measurements are usually made during a single beam pulse in one of the transfer lines or in the rings, where the beam is allowed to circulate only once (a beam stopper being lowered after the first revolution). The measuring units are sensitive to a current of 2×10^{10} protons/cm^2, and can equally well be used for fast beam pulses (up to 2 μs) consisting of either a few or all of the twenty bunches of protons from the PS and for long pulses (over 100 ms) for measurements on slow ejection. In the latter case, it is possible to make a series of measurements during a single ejection at times separated by 10 to 20 ms, so that fluctuations in emittance can be observed (provision for this measurement is, however, limited to the transfer of slow ejection pulses from the PS towards the West Experimental Hall).

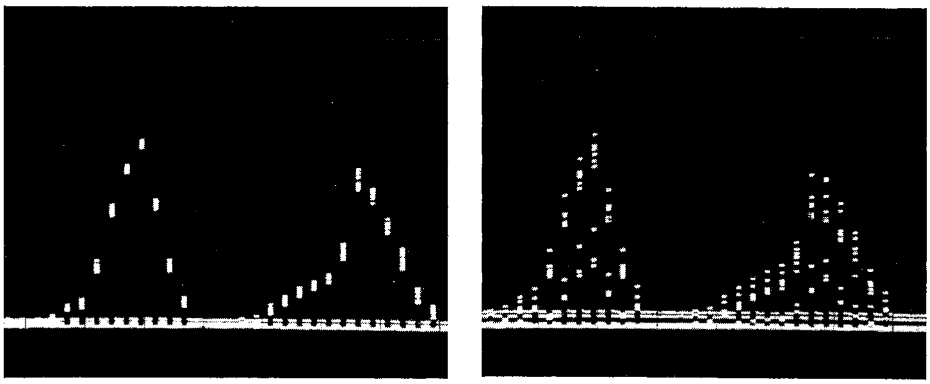
The spatial resolution of the measurements is given by the space between the strips, which varies between 3 and 5 mm according to the unit concerned. With the interpolation technique mentioned above this can be improved by a factor of two and the results can be further interpolated numerically.

With the present system the signals provided by each strip are amplified and converted to numerical form, the numerical signals being collected in succession. They are then sent to an oscilloscope which produces a histogram like the one shown in the figure.

In its final version, the system will be directly connected to a computer which will process the signals to give an immediate reading of the beam emittance at various points, either displayed on a cathode-ray tube or

1. Examples of photographs taken on the oscilloscope giving beam profiles during a short pulse.

2. The detector itself; the horizontal and vertical strips and the detection electrodes are clearly visible.



printed. The equipment is scheduled to be fully operational during the summer of 1971.

Neutrinos at the ready

The neutrino beam-line has been refurbished ready to serve the large heavy liquid bubble chamber Gargamelle for a new neutrino experiment. The beam-line was tested at 24 GeV in November 1970, and a second series of tests (at 19 GeV) have just been successfully completed.

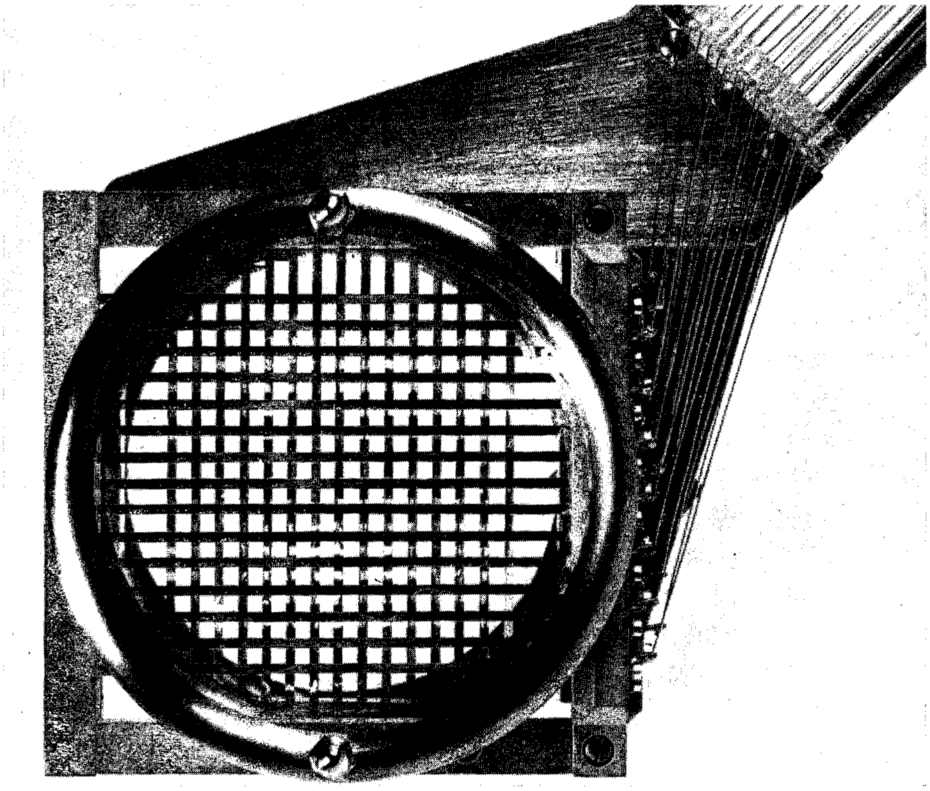
Neutrinos are extremely abundant particles, pouring out from many extra-terrestrial sources and from many sources on earth, but since they hardly interact at all with other particles (most of them passing through the earth without being absorbed), it is very difficult to observe their behaviour.

In order to study them, they need to be generated with as intense and as concentrated a flux as possible, which is then aimed at a large detection system. For the coming experiment the detector will be the new heavy liquid bubble chamber, Gargamelle, the largest of its type so far built, with a useful volume of 12 m^3 and a length of 5 m.

The neutrinos are generated from the decay of kaons and pions which themselves are produced in the collision of protons ejected from the PS against a target. The decays producing neutrinos are :

$$K^+ \rightarrow \mu^+ + \nu_\mu \text{ and } \pi^+ \rightarrow \mu^+ + \nu_\mu$$

To obtain the highest possible neutrino flux, a very long target is exposed to the ejected proton beam to give the kaon and pion 'neutrino parents'. Since these emerge from the target in all directions, a special focusing system is required so as to capture as many as possible and to guide them in the direction of the bubble chamber. The first unit of



2.

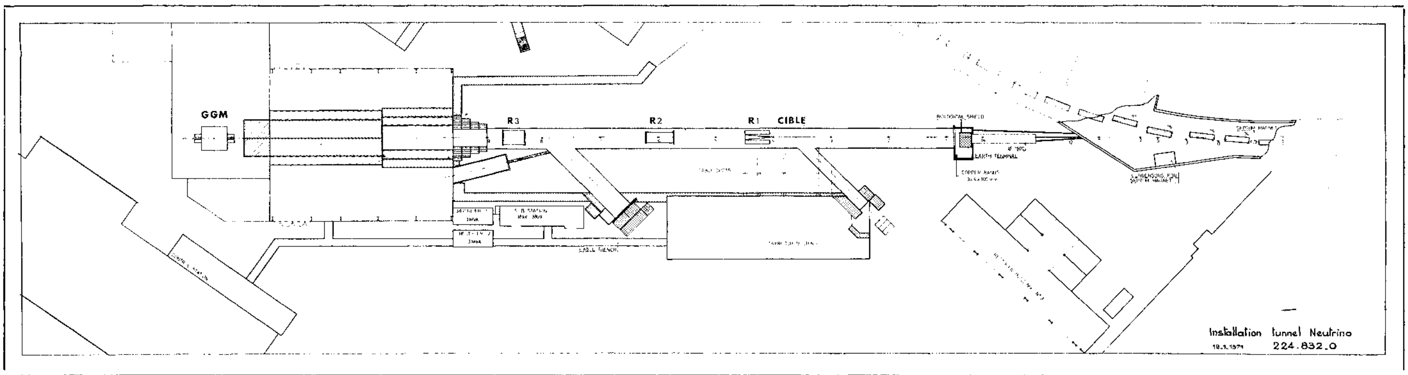
the system is a magnetic horn, consisting of a specially shaped aluminium cone through which passes a high intensity current (about 340 kA) creating lines of force which curve the trajectories of the particles emerging sideways from the target, positioned inside the horn, into the forward direction.

The focusing system is completed by two further magnetic reflectors arranged downstream. The neutrino parents are thus aimed at the chamber and, when they decay, the neutrinos which are produced continue in the same direction. (Since the neutrino carries no charge it is not possible to do any focusing of the neutrino beam itself.) Apart from this focusing system, an extremely important component of the beam-line is the very thick steel shield designed to stop all particles other than neutrinos — protons, kaons and pions, which are stopped by a few metres of shielding, and above all, muons, which are stopped by about 22 m of shielding.

A compromise had to be stuck between two opposing requirements. On the one hand, the distance between the target and the shield must be as great as possible to allow the largest possible number of neutrino parents to decay. The decay length for a pion is about 60 m/GeV, and thus a distance of 1440 m would be needed for the decay of half the pions if they had an energy of 24 GeV. On the other hand, the resulting neutrinos must be concentrated in the volume of the chamber, which is helped by a shorter beam-line. The beam-line parameters for the 1971 experiment (with the corresponding 1967 figures in brackets) are: decay tunnel about 70 m (57 m), shield thickness 22 m (20 m), distance from target to bubble chamber centre about 96 m (78 m), target length 90 cm (60 cm), target material beryllium or

5/2a

Plan of the new neutrino beam-line. On the left is positioned the heavy liquid bubble chamber, Gargamelle, behind a steel shield 22 m thick. The proton beam is ejected from the synchrotron on the right and directed onto a target positioned inside a magnetic horn. Two further focusing units (R) guide the neutrino parents towards the chamber.



aluminium (boron carbide), horn current 340 kA (300 kA).

The new neutrino beam-line uses most of the components of the previous one (see vol. 6, page 215). The main differences are :

a) the shape of the focusing horn has been slightly improved

b) the horn can now be changed for a spare (since this is a comparatively fragile unit because of the high current density).

The replacement of the horn involves disconnecting the water and power connections, moving a 100 tonne surrounding shield, removing the target, moving the horn with the aid of the overhead crane (using TV cameras to supervise and control the operation), and then installing the replacement horn in the reverse sequence. All this takes only half an hour as against at least a day which was previously needed because of the need to allow the area to 'cool down' before starting work.

The power cables supplying the horn, the insulation of which was damaged by radiation, have been replaced over a length of 13 m by long sandwich plates with a cross-sectional area of 400 $\times$ 15 mm^2 (separated by a few millimetres of insulating material).

A new steel shield built of parallelepiped blocks (3000 tons, 22 m long) has replaced that of the old line. Transverse channels have been built through the shield where different types of detectors providing information of the muon spectrum (and thus of the neutrino spectrum) are installed. The detectors, which are connected to an on-line computer will monitor the beam so that any necessary corrections may be made. A mercury-filled tube passes through the shield along the beam trajectory and can be partially emptied periodically to allow muons through in order to calibrate the chamber. There is also an oblique passage from which the shielding can be removed to allow the chamber to be supplied with high-energy proton, pion and muon beams when required.

The number of neutrino events anticipated in Gargamelle will be 1 per 20 photographs, as against 1 per 1000 during the last neutrino experiment in 1967 (using the CERN 1.2 m heavy liquid chamber). This is due to the increased volume of the chamber, the lengthened distance between target and chamber, and the fact that the experiment will be carried out at an initial proton energy of 24 GeV instead of 20 GeV.

Progress on the commissioning of Gargamelle itself is proceeding satisfactorily, and the first tests with neutrinos are due to begin at the end of January. Two six-hour testing periods, each taking all twenty bunches from the PS are scheduled for January and February. The neutrino experiment is scheduled to begin early in May.

Council elections

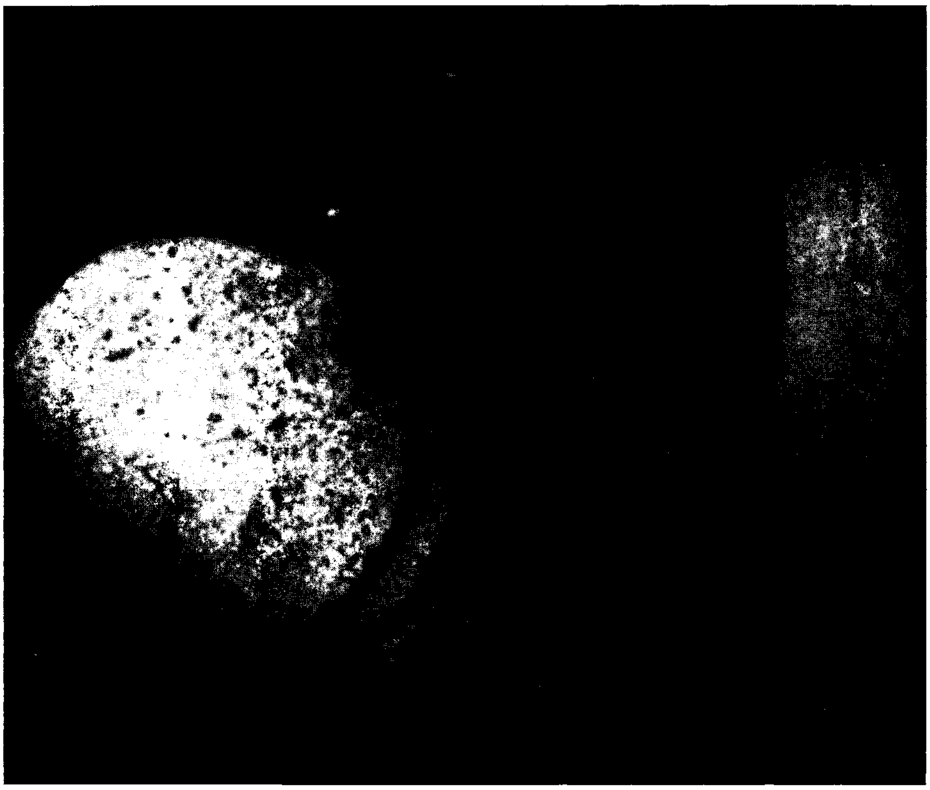
At the 45th Session of the CERN Council held on 22 December, elections were held for the senior positions of the Council and its Committees. Professor E. Amaldi (Italy) was re-elected President of the Council for the coming year and the Vice-Presidents, Mr. A. Chavanne (Switzerland) and Mr. H. Haunschild (Federal Republic of Germany) were also re-elected.

After several years of excellent service as Chairman of the Finance Committee Professor W. Kummer (Austria) is succeeded by Mr. P. Levaux (Belgium). Professor W. Gentner (Federal Republic of Germany) remains Chairman of the Scientific Policy Committee.

The first tests with the hyperon bubble chamber HYBUC (see vol. 10, page 353) filled with liquid hydrogen began on 16 December. The aim was to check the hydrogen filling procedures and the thermodynamic properties of the chamber with the expansion system in operation. A fair amount of nitrogen crept in with the hydrogen and a heap of nitrogen 'snow' meant that conditions were far from clean.

Nevertheless the temperature regulating and expansion system worked well and the hydrogen volume was made sensitive with a static pressure of 5 atmospheres and a pressure swing of 3 atmospheres. The expansion pulse width was 15 ms. For fun, a cobalt radioactive source was brought alongside to give gamma rays into the chamber and electron tracks were detected as well as an occasional cosmic ray.

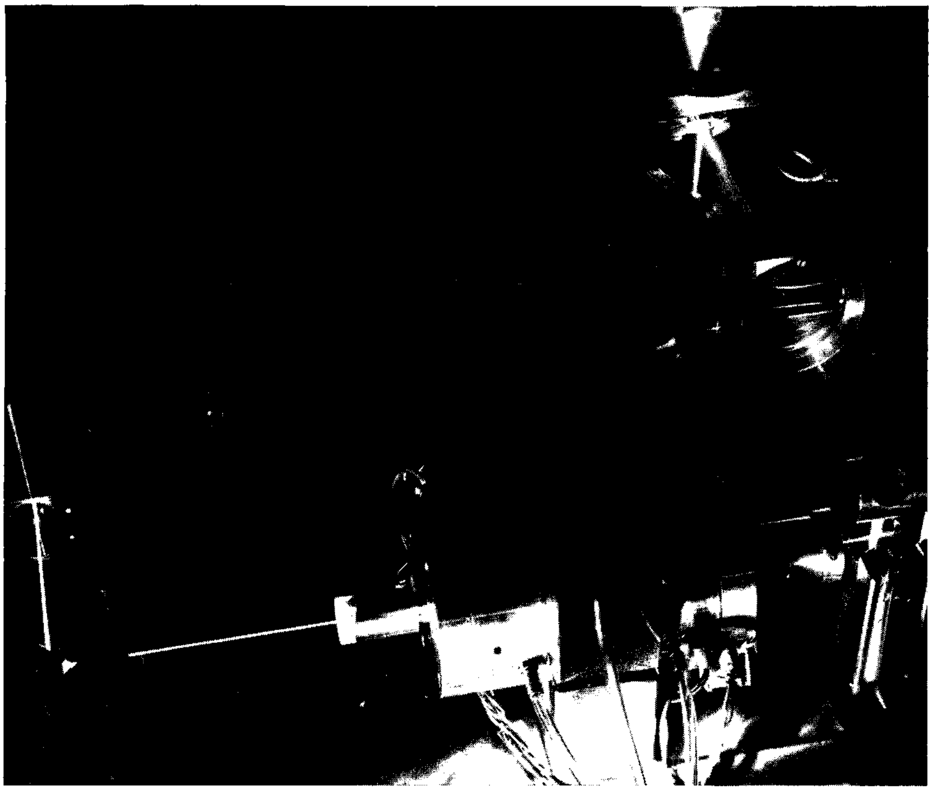
The photograph is blown up from a polaroid. It is fogged in the lower part by the nitrogen snow but this is not a serious problem. Production of an electron pair can be seen. The chamber is now being cleaned up and further tests will be carried out shortly. The next big event is the expected arrival near the end of January of the superconducting magnet from the USA which is designed to produce a field of at last 11 T in the hydrogen volume.



The Instrumentation Group of the Track Chambers Division has carried out a series of tests to evalute the use of a laser beam in an automatic film measuring machine. This type of device has been developed particularly by a group at Cambridge University who have christened it 'Sweepnik' (see vol. 9, page 206). Special lens and prism arrangements produce a tiny rotating line of light which is swept over the film to search for tracks.

In the CERN tests a helium-neon laser, with a strength of 1 mW, produced a continuous beam of light. In the photograph the laser is on the left and the light beam is initially vertical and then bent horizontal to the right where it is formed to give a thin line 1 mm long and 5 μm wide which is made to rotate over small areas of the film (the film plane being top right) by means of small plane parallel spinning glass plates. The film can be displaced along x and y directions, so that the line can cover all interesting regions of the film. Plans for future developments (which it is not now intended to carry out) were to control these movements by a small on-line computer in order to follow tracks automatically.

A particular advantage of this type of device is that, thanks to the high intensity of the laser beam, a high signal-to-noise ratio is achieved, making it possible to follow feeble tracks on low-contrast film. Due to the philosophy of the track-following procedure, first developed in Sweepnik, only modest on-line computing facilities are required.



Around the Laboratories

DUBNA
Possible future projects

Possible modifications to existing machines and new machine projects in the comparatively low energy but high intensity region have been under study at the Joint Institute for Nuclear Research, Dubna, in recent years with the aim of improving the facilities for nuclear research at the Institute.

The project most likely to go ahead is an improvement programme on the existing 680 MeV synchro-cyclotron. Detailed plans are being prepared to have four spiral ridges on the magnet which will have field varying from 1.2 T at the centre to 1.63 T at the outside. The peak energy will be raised slightly to 700 MeV but the important improvement with the spiral ridge machine will be an increase of the internal beam current to 50 μA yielding beams of pions and protons 50 to 100 times more intense than are currently available.

The r.f. system will have a frequency swing three times smaller than at present which will help in achieving high accelerating voltages (50 kV) without too much strain on the r.f. rotating condenser. The ion source will be lowered vertically through a hole in the top centre of the magnet and it will be possible to exchange the normal proton source for a polarized proton source. Two extraction systems (regenerative and magnetic channel types) are being studied.

It is intended to implement this improvement programme at the end of 1972 when the machine will be shut down for one and a half years. It should then be in operation again for physics by the end of 1974.

Another project under study is an isochronous cyclotron to give high intensity (up to 100 μA), monoenergetic beams ($\Delta E\ 10^{-4}$) of protons, deuterons, alphas and lithium ions. The present design is for a separate injector feeding into a circular machine in four sectors with two Dees and an energy gain of 100 keV per turn. This will give a separation between the orbits of 3 mm at the outside circumference for high extraction efficiency. The machine will yield an energy of 100 MeV for protons.

Finally an exotic project for a very high current (500 mA) relativistic cyclotron with strong focusing, reaching a peak energy of 1 GeV, has reached the stage where an electron model has been built. The model has a radius of just over 1 m and accelerates electrons to 400 keV. Electron currents of 600 μA have been achieved which is equivalent to 300 to 400 mA of protons.

PRINCETON
Count out

Unless a fairy godmother arrives on the scene very soon the Princeton-Pennsylvania Accelerator Laboratory is entering its last year of physics. As reported in April 1970 (vol. 10 page 120) an 'orderly shutdown' of the 3 GeV fast cycling proton synchrotron was decided in the context of tightening budgets in the USA accelerator centres.

From a once busy Laboratory of some 400 people the staff has now been reduced to about 60 (mostly operating personnel) and there is no commitment of funds from any source for fiscal year 1972 (beginning 1 July 1971). Favourable noises have been heard from the National Science Foundation but with little hope of money before fiscal year 1973 and efforts have been made to encourage NASA to support the Laboratory as a centre for heavy ion research. The machine is capable of accelerating heavy ions to energies of about 1 GeV per nucleon. This would however require some conversion of the accelerator particularly to achieve a vacuum in the 10^{-9} torr range.

The future space programme in the hands of NASA may well be influenced by more knowledge about what damage heavy ions can cause, not only to human beings but also to those vital semiconductor chips in rocket instrumentation. But there is no sign of the money which would be needed to turn the accelerator into a good machine for heavy ion research.

At present the machine schedule calls for full scale operation (21 shifts per week) for the experimental programme until the end of March. Perhaps the most interesting item in the programme is a high precision measurement of the differential cross-section of the interaction of a neutron and a proton to give a deuteron and a gamma

$$n + p \rightarrow d + \gamma$$

A primary beam of deuterons, accelerated to a selected energy in the synchrotron, strikes an internal target stripping off the protons. This yields a neutron beam continuing in the forward direction with practically the same velocity as the deuterons. A long flight path and the synchrotron r.f. structure are used to achieve a momentum resolution of better than 1% in the intense neutron beam which is produced.

The experiment is now taking data and the measurement will be used for comparision with the inverse process (gamma on deuteron giving neutron and proton) as a check on the validity of time reversal invariance. A few years ago the comparison seemed to indicate that time reversal was violated but it was realized that some of the measurements were not very reliable.

Ironically the accelerator is performing better than ever. The average intensity is 5×10^{11} protons per second with spill duty factors of 10%. Beams of protons, neutrons and alphas feed the experiments. The magnetic field flat-topping equipment (see vol. 10 page 16) has worked well and full flat-topping was achieved for a few shifts. However before it could be made fully operational the people responsible had to leave. Another improvement has been the replacement of the ferrite rings in the drift tube section of the r.f. system with a ferrite of much higher permiability obtained from Japan. With this new ferrite the total frequency range of the accelerator r.f. system is from 1 to 30 MHz.

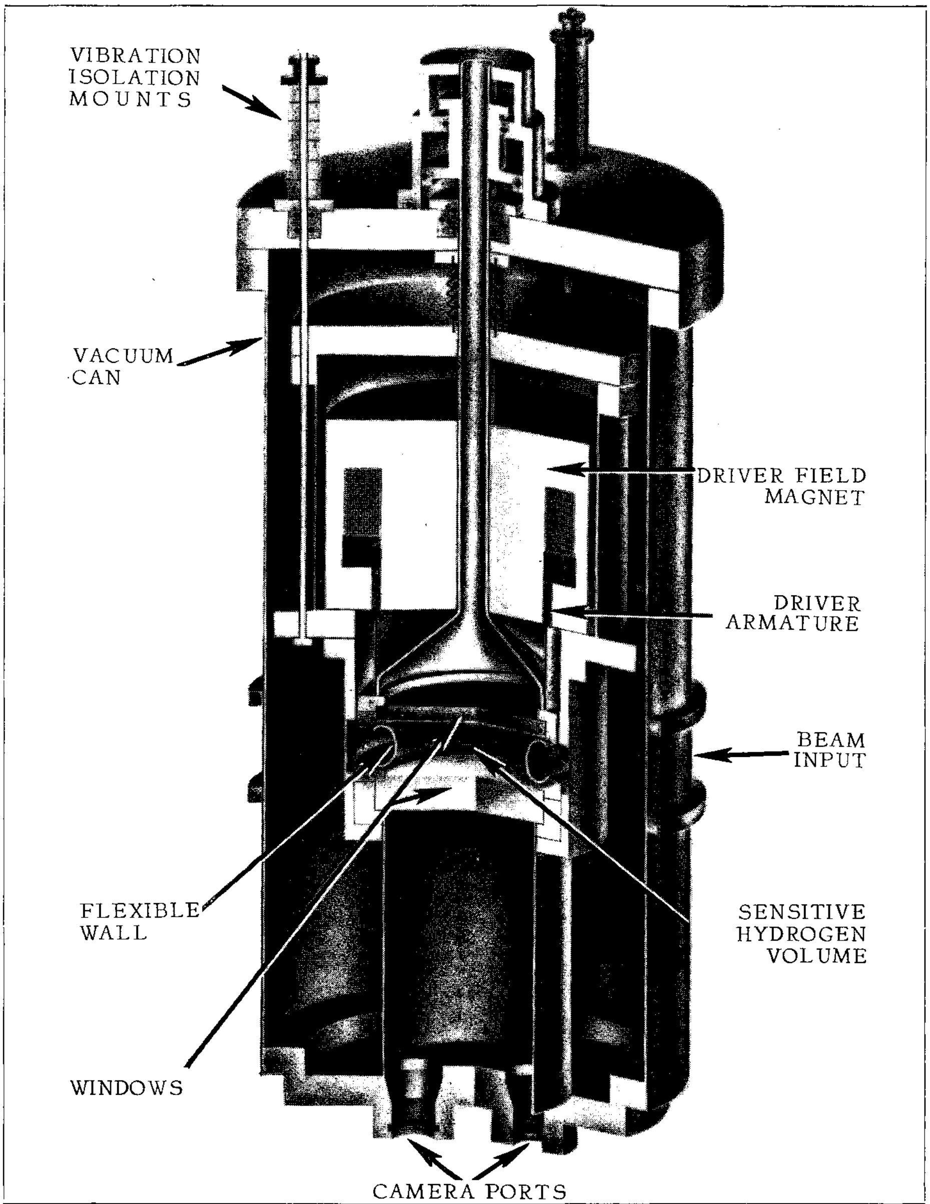
Arrangements for the dispatch of equipment to be used elsewhere are being made and little bits of Princeton will be found at Brookhaven (magnets), Los Alamos (power supplies) and Argonne (beam separators).

STANFORD
Rapid cycling bubble chamber

In the last couple of years there has been growing interest, paralleled by growing mastery of the necessary techniques, in having bubble chambers taking pictures at much faster rates.

At one end of the scale the 'old' bubble chambers are having their expansion systems pepped up so that they can take pictures twice (like the CERN 2 m chamber) or more times (5 at the Argonne 30 inch chamber; 12 at the SLAC 40 inch chamber; 19 at the Princeton 14 inch chamber) during the spill of accelerated particles from a single machine pulse. Here the aims are particularly to record more events in a given time or to shorten the time necessary for the experiments. At the other end of the scale there are attempts to make bubble chambers take pictures at rates in excess of 20 per second. Here the aims could be the same or (much more probably) could be to integrate the chamber into a counter system where the counters help decide whether the event of interest has taken place and thus whether the picture is worth having (this was done also on the Argonne and Princeton chambers mentioned above). It could simplify measurement and analysis problems and open up the possibility of using bubble chambers efficiently in the study of rarely occurring events.

We need to say a word about the nomenclature which seems to be becoming sanctioned by usage if not by logic. This latter category of chambers are called fast cycling. They can be sub-divided into sonic and ultrasonic (where sound fields are producing the high speed pressure changes) and rapid cycling (where the chamber volume is not



Model of the rapid cycling bubble chamber being built at the Stanford Linear Accelerator Centre showing the disposition of the major components.

(Photo SLAC)

acoustically resonating). We will leave the sonic and ultrasonic alone for the time being but are likely to be coming back to them soon, following a one day meeting on Ultrasonic Bubble Chambers organized by the UK Institute of Physics and the Physical Society to be held at the Rutherford Laboratory on 18 March.

Quite a lot of the pioneering work on rapid cycling bubble chambers has been done at Stanford (see, for example, CERN COURIER vol. 9, page 238). They had a 5 cm chamber working at 90 Hz in mid-1969 and have since had a 10 cm chamber also working at 90 Hz continuously over 20 minutes and still giving good quality pictures. Also, Saclay have had a 40 cm chamber cycling once every 22 ms in spasms of 15 expansions but turbulence and heating along the piston shaft have limited steady operation to 5 Hz. A further project is to convert the 14 inch Wisconsin chamber to operate at 30 Hz in one second spasms (after which it rests for 3 s) to be used in the Batavia experimental programme.

But the peg for this short article is the latest move in the Bubble Chamber Development Group at Stanford where, building on their successful experience with the small models, a rapid cycling hydrogen bubble chamber to be used in the physics programme at the 20 GeV electron linear accelerator is under construction. The hydrogen volume will be 375 mm in diameter and 140 mm high.

The camera looks from below. The exit window is of low mass and particularly wide so that particles can emerge over a wide solid angle to be recorded by counters mounted outside the chamber. The expansion system operates with electromagnetic drive (rather similar to the coil of a loudspeaker but of much higher power) and the piston acts from the top of the chamber. Its natural resonant frequency is 120 Hz but, to ensure better recondensation of the bubbles from cycle to cycle, it wil be driven at 60 Hz giving less expansion on alternate cycles of the natural frequency (due to damping) when it is not driven.

The chamber is scheduled to be ready for testing in June.

JINR School

It has been the tradition for many years for CERN to organize a Summer School aimed particularly at young experimental physicists. In 1970 this School was organized in collaboration with the Joint Institute for Nuclear Research, Dubna, and was held at Loma Koli in Finland. This year JINR will take over the organization in collaboration with CERN. The 1971 JINR School of Physics will be held at Varna, Bulgaria, from 13 to 27 June.

The programme of lectures has been arranged as follows: Inelastic particle interaction theory (D. Shirkov, Dubna), Multiparticle production at high energies (A. Bialas, Cracow), Multiparticle production on nuclei at high energies (V. Barashenkov, Dubna), Application of multiple scattering theory (O. Kofoed-Hansen, CERN), Electromagnetic and weak interactions (J. Prentki, CERN), Schrodinger's equation for relativistic two-body processes (I. Todorov, Dubna), Phenomenological approach to high energy processes (V. Matveev, Dubna), Non-singular potential approach (M. Mestverishvili, Serpukhov). There will also be lectures on the research programmes at Dubna, CERN, Serpukhov and Novosibirsk. Special lectures may be given by B. Pontecorvo, Dubna, and Ch. Christov, Sofia. Informal discussion groups will be led by P. Darriulat (CERN), N. Mateev (Sofia), Ch. Palev (Sofia), K. Schilling (CERN), and V. Toneev (Dubna).

Correspondence concerning the School should be directed to Moscow Head Post Office, P.O. Box 79, JINR, V.S. Shvanev, USSR, or Dr. W.O. Lock, Personnel Division, CERN, CH-1211 Geneva 23.

ICTP Courses in 1971

The International Centre for Theoretical Physics at Trieste has organized courses for 1971 on nuclear theory and on computing as a language of physics.

The Nuclear Theory course runs from 13 January to 12 March under the direction of L. Fonda and G. Ripka. Topics covered are — Fundamental Theories of Nuclear Spectroscopy, including dynamics of effective interactions, transfer reactions, models of nuclear excitations, etc... and Common Frontiers between Nuclear and Solid State Physics, including transient field effects, string effects, etc...

The seminar course on Computing as a Language of Physics will take place from 2 August to 20 August. Topics covered will include — partial differential equations in classical physics, particle calculations and the classical N-body problem, quantum mechanical calculations, methodology of computational physics and various advanced applications of computers to physics.

The Centre will also undertake research in elementary particle physics, solid-state physics and nuclear physics during the year.

CC goes SI

As from this issue, CERN COURIER will try to adhere more religiously than in the past to the SI system of units (Système International d'Unités). The SI system was accepted as the standard as long ago as June 1966 when the International Organization for Standardization met at Elsinore in Denmark and, from the beginning of 1968, many journals of the scientific and technical press have encouraged and even insisted on their use.

We have been rather more tentative, partly because our function is obviously different from the formal scientific press. We might even say that it is as important for us to be understood as to be right! Some of the SI units have taken time to settle in and many of the previously established ones will take a generation to fade away. There may still be physicists who wouldn't recognize a newton if it fell on them (a matter of some gravity) and there are still Angstroms and torrs around in profusion. Also our Anglo-Saxon friends still use their feet.

However it is time we were more conscientious in applying the SI units and we present here a brief run through of major features of the system. (A readable little book called 'Understanding SI Metrication' by R.M. Diamant is an excellent fuller guide). There will remain a few deliberate violations — for example, we will for the time being stick to torr for pressure since newtons per square metre is still in rare use (1 torr = 133.3 N m^{-2}), and established names like the Argonne 12 foot bubble chamber will not become the Argonne 3.66 metre bubble chamber.

There are six basic units

Length	metre	m
Mass	kilogramme	kg
Time	second	s
Current	ampère	A
Temperature	kelvin	K
Luminous intensity	candela	cd

All multiples and sub-multiples of these go in steps of a thousand

Multiples	10^3	kilo	k
	10^6	mega	M
	10^9	giga	G
	10^{12}	tera	T
Sub-multiples	10^{-3}	milli	m
	10^{-6}	micro	μ
	10^{-9}	nano	n
	10^{-12}	pico	p

Numbers are written in blocks of three

3 576 210.185 2

Supplementary units are

Angle	radian	rad

(a dimensionless number — 2π rad in angle at centre of a circle)

Solid angle	steradian	sr

(a dimensionless number — 4π sr in solid angle at centre of a sphere)

There are also permitted units which have survived because they are widely used, because they are of convenient general size or because they have specialized use

Time	year, month, day, hour
Angle	degrees, minutes, seconds of arc
Length, area	centimetre, decimetre, are (100 m^2), hectare (10^4 m^2)
Pressure	bar (100 kN m^{-2})
Viscosity	poise, stokes
Nuclear physics units	barn, curie
Energy	electron volt
Length	light year
Volume, mass	litre, tonne (10^3 kg), gramme

And finally derived units of which we list some major ones

Area	m^2	multiples and sub-multiples go in steps of 100
Volume	m^3	multiples and sub-multiples go in steps of 1000
Temperature	°C	degree Celsius, still retained, derived as (K - 273.15))

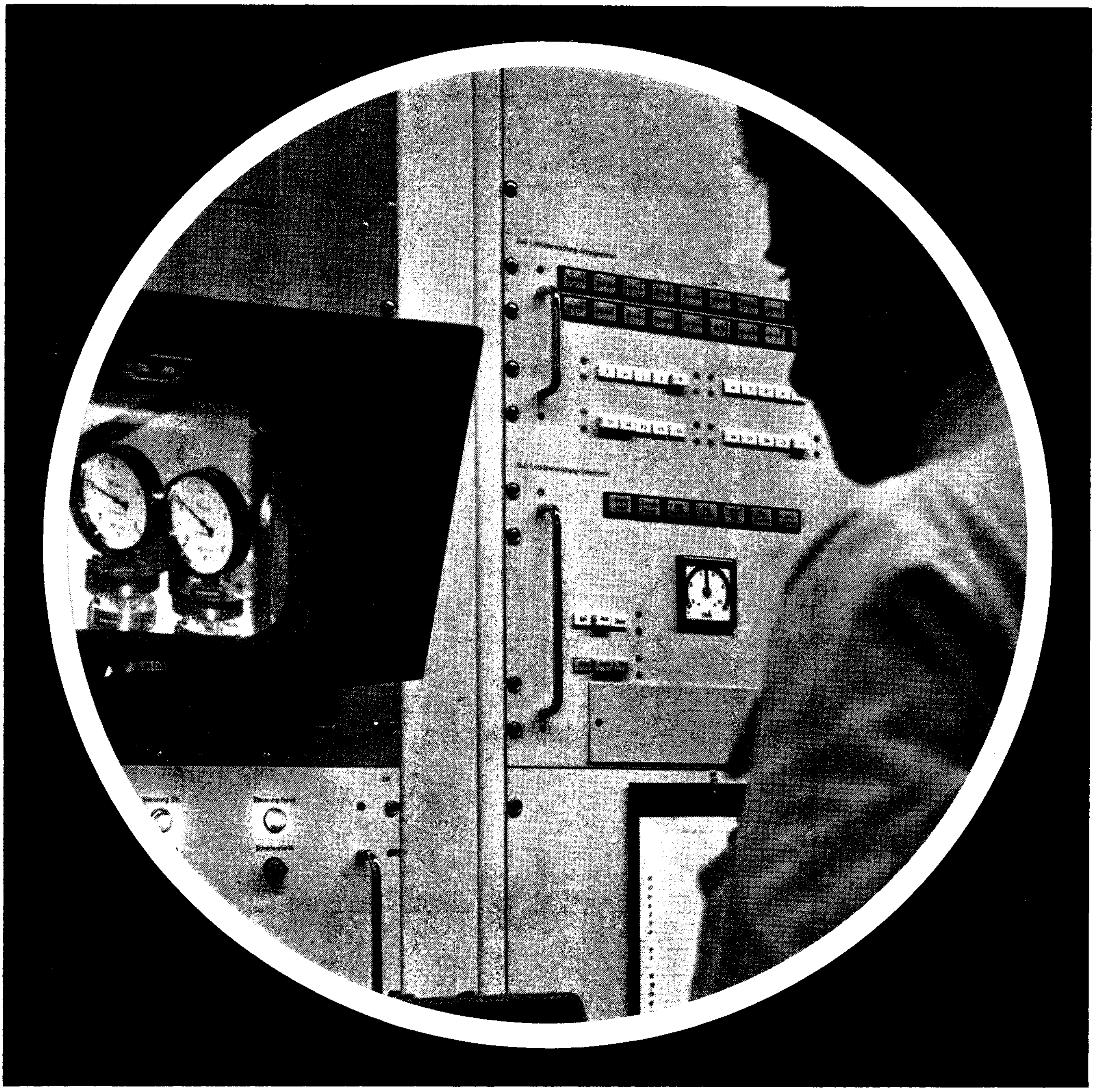
(Note: absolute temperature is written as K or °C, temperature difference is written as °K or deg C)

Force	N	the newton is the only unit, derived as N = 1 kg m s^{-2}
Pressure	N m^{-2}	(the bar = 10^5 N m^{-2} is permitted and is about equal to 1 atmosphere pressure)
Energy	J	the joule (= 1 N m)
Power	W	the watt (= 1 J s^{-1})

(Other derived electrical units are the volt V = W/A, the ohm Ω = V/A, the coulomb C = A s, the farad F = A s V^{-1}, the henry H = Ω s)

Density of magnetic flux	T	the tesla (= Wb m^{-2})
Magnetic flux	Wb	the weber (= V s)
Frequency	Hz	the herz (cycles per second)

Practically all these units will be immediately recognized and we hope that the use of the few which are not so well established will not add confusion to our pages.



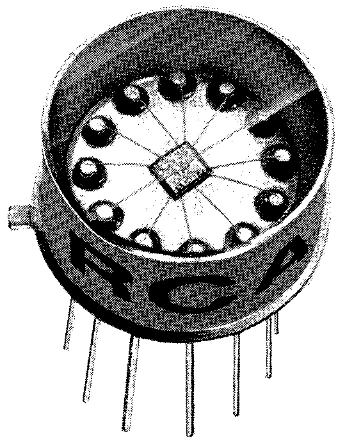
Tips + Topics

RCA

CA 3062 - Light sensor and power amplifier on one IC chip

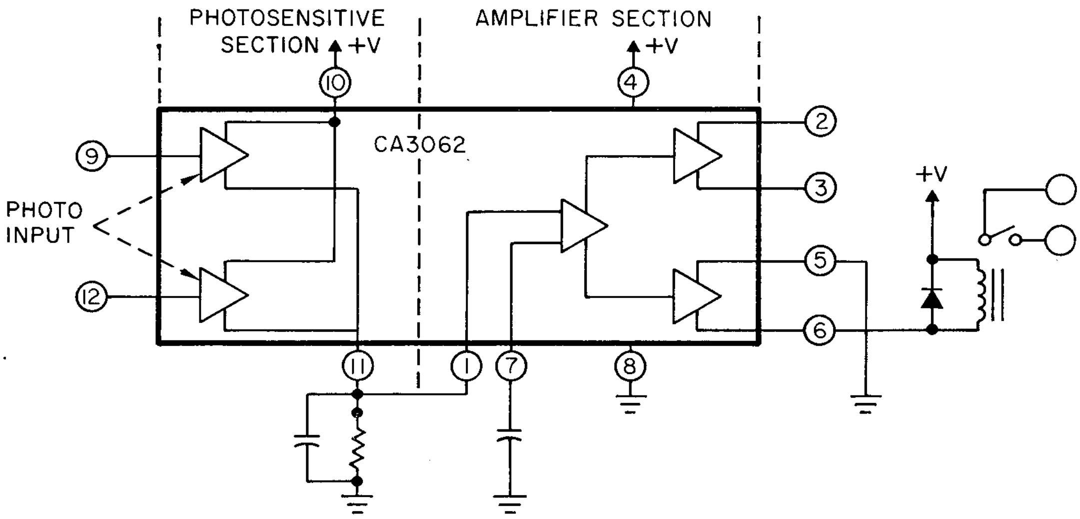
For :

- ☐ counters
- ☐ sorters
- ☐ level controls
- ☐ intrusion alarms
- ☐ edge monitoring
- ☐ position sensor
- ☐ isolators
- ☐ inspection



Features :

- ☐ Darlington = connected photosensitive pairs
- ☐ 100mA output current capability (drives a relay or thyristor directly)
- ☐ 5 to 15 Vdc supply voltage range
- ☐ compatible with RCA = 40736 IR emitter



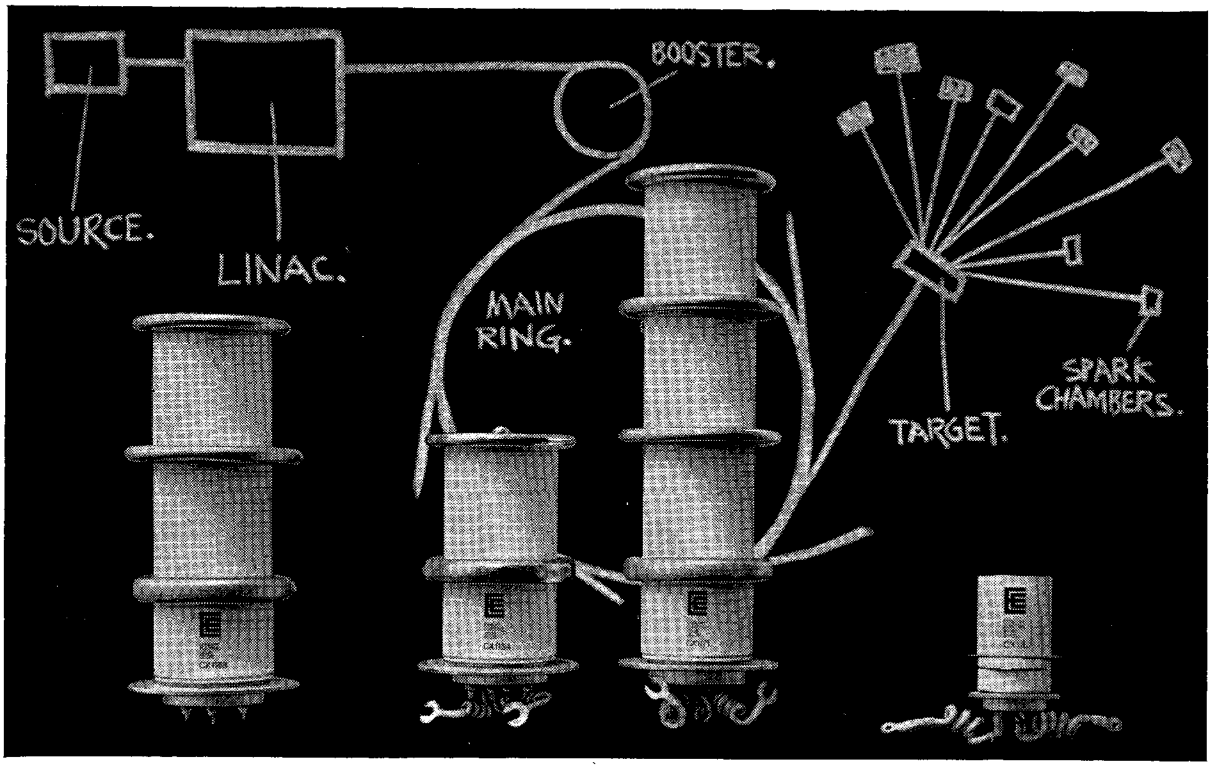
The CA 3062 consists of two parallel-connected photosensitive Darlington pairs which drive a differential power amplifier to provide a normally-off and normally-on output in response to a light input. Available in a compact, window-ended TO-5 style package, the CA 3062 has 100mA output current capability, and can be operated at supply voltage in the range of 5, 15 volts dc. Il is compatible with RCA's 40736R infrared emitter. Use it for counter and position sensors, optical tachometers, limit detectors, level scanners, paper weg sensors, wheel balancers, and similar devices. For further details ask for datasheets or have a visit at our booth at the INEL 71.

INEL 71 : hall 23
booth 236 and 341

P.O. Box 485, 8021 Zurich, Tel. (051) 42 99 00

baerlocher

EEV thyratrons give greater accuracy and better performance in three major nuclear physics applications:



Linear accelerators

☐ EEV thyratrons can withstand peak inverse voltages up to 20 kV following a pulse.
☐ Their operation is unaffected by small reservoir voltage variations.
☐ EEV thyratrons need no servicing and give trouble-free operation in oil-filled equipment.

Particle accelerators

☐ EEV thyratrons ensure reliable firing. They give nano-second accuracy.
☐ There are very few missing pulses.
☐ They require no external gas supply.
☐ Because they have an annular current flow EEV thyratrons can switch peak currents very rapidly without risk of arc extinction. When fitted into coaxial housings rates of rise of current up to 100kA/µsec are possible.

Spark chambers

☐ Long life is important for spark chamber operation – and EEV thyratrons have given 10,000 hours service in some cases.
☐ Spurious firing is virtually eliminated.
☐ Jitter is kept as low as 1 ns.
☐ They make possible repetition rates of up to 50 kHz due to very rapid deionisation characteristics.
☐ EEV thyratrons operate over a wide range of H.T. voltages at currents up to 10 kA without change in characteristics – so drive units may be used with different chambers.
☐ The low trigger voltage means that simple firing circuits are possible.

English Electric Valve Co Ltd,
Chelmsford, Essex, England.
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Grams: Enelectico Chelmsford.

To: English Electric Valve Co Ltd, Chelmsford, Essex, England
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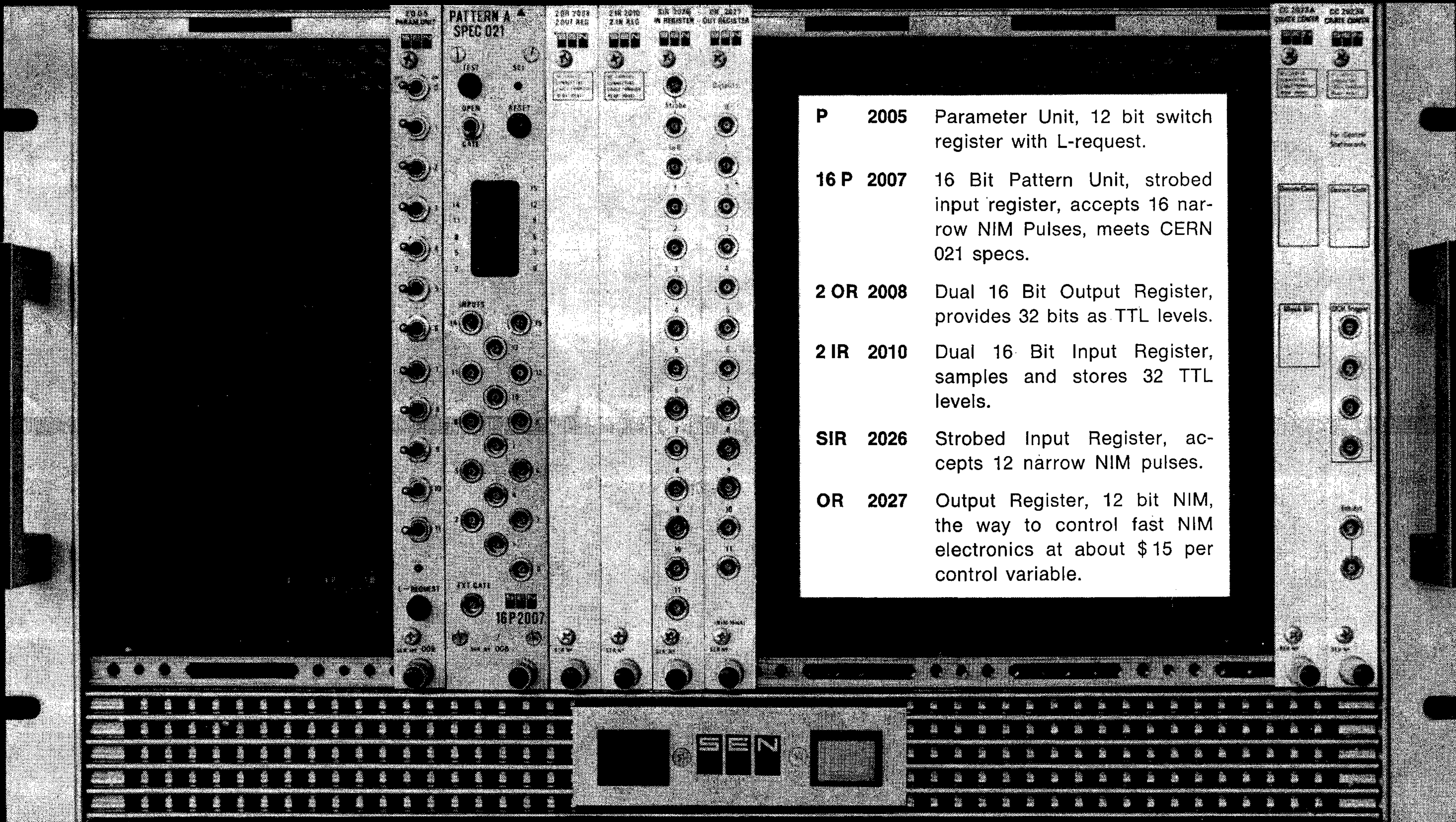
CRC9

Now the I/O REGISTERS

Have you seen our SCALERS last month?

SEN CAMAC



P	2005	Parameter Unit, 12 bit switch register with L-request.
16 P	2007	16 Bit Pattern Unit, strobed input register, accepts 16 narrow NIM Pulses, meets CERN 021 specs.
2 OR	2008	Dual 16 Bit Output Register, provides 32 bits as TTL levels.
2 IR	2010	Dual 16 Bit Input Register, samples and stores 32 TTL levels.
SIR	2026	Strobed Input Register, accepts 12 narrow NIM pulses.
OR	2027	Output Register, 12 bit NIM, the way to control fast NIM electronics at about $15 per control variable.

Watch out for our CRT DISPLAY modules in the next month's copy.

SEN ELECTRONIQUE

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France: SAIP, 38, rue Gabriel Crié - 92 - Malakoff
Germany, Benelux: HERFURTH GmbH, Beerenweg 6/8 - D 2000 Hamburg 50 (Altona)

Italy: ORTEC-Italia SRL - Via Monte Suello 19 - 20133 Milano
Sweden: POLYAMP AB - Toppvägen 20 - Jakobsberg
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Demonstration and discussion at APS — Booths 42-43

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